advantages of discussing the broader implications of decisions that were made in the Guidelines (financial, political, based on reliability, etc.). The team will have the commentary reviewed for accuracy by a panel of experts set up by the Steering Committee. This panel will include members of the **SPP, NPP** and **RMP** teams.

Personnel: Design professionals, Researchers,

Priority: Essential
Budget: $500,000
Duration: 2 years

Task 5.2.3 – Develop administrative guidelines for building officials

Description:

The team will establish administrative provisions for the use of PBSD by building officials. It will detail the process by which buildings, including structural and nonstructural components, are reviewed, plan checked and field inspected. The team will also develop tools for building officials to ease the burden of reviewing PBSD design. The team will consider the benefits of third party plan check and peer review and other means of streamlining the process while maintaining quality

Personnel: Design professionals, Owners, Building officials, Government agencies

Priority: Optimal
Budget: $200,000
Duration: 1 year

Task 5.3 – Implement a verification program

Task 5.3.1 – Run examples to check accuracy of provisions

Description:

The team will establish subgroups to verify the accuracy of the design and analysis procedures. The subgroups will create and test a series of parametric examples. The team will set up a means by which the results of the testing can be checked for accuracy and acceptability. The team will identify and make necessary changes in the procedures in cooperation with the technical product teams.

Personnel: Design professionals, Researchers, Building officials,

Priority: Essential
Budget: $600,000
Duration: Throughout the project

Task 5.3.2 – Compare resulting designs and costs against current methodologies

Description:

The team will evaluate the effects of the resulting guidelines on each of the major stakeholders, looking at costs, level of effort and responsibility. A series of example applications will be developed and compared against current design techniques. The various methods that are developed will be calibrated against each other. Calibration will consider at least: the effort to implement, resulting

performance and expected construction costs. Information from the **RMP** will be incorporated into the calibration study. The team will establish subgroups to carry out these studies, and will develop a standard reporting method by which the results can be quantitatively compared. If the team decides that the results diverge too significantly from existing methodologies, revisions to the procedures will be made, or a schedule for incremental application of the procedures will be developed.

Personnel: Design professionals, Researchers, Financial interests

Priority: Essential
Budget: $400,000
Duration: Throughout the project

Task 5.4 – Develop procedures for quality control during construction

Description:

The team will write a set of guidelines for maintaining quality during construction. Information on reliability and uncertainty developed in the **SPP** and **NPP** will be used to evaluate the various stages of construction. The team will address such issues as material fabrication and inspection, installation, testing, uniformity in construction practices, field changes, etc. The goal is to provide a clear statement about the need for a high level of construction quality, and to provide standard procedures to attain this quality. It may be desirable to permit different levels of quality control based on expected performance or on building usage, etc.

Personnel: Design professionals, Contractors, Material Suppliers, Owners, Building officials

Priority: Optimal
Budget: $300,000
Duration: 2 years

Task 5.5 – Develop a plan for verifying nonstructural component design and installation

Description:

The team will develop a standard format for checking the adequacy of nonstructural component and system design, manufacture and installation. Much like peer review and inspection procedures for the structure, this system will be designed to track nonstructural elements through a similar process. The team will establish a system for identifying and training qualified inspectors and reviewers. The team will use the information developed in the **NPP** to make easier reevaluation of existing components and determine expected performance.

Personnel: Design professionals, Contractors, Material suppliers, Building officials

Priority: Optimal
Budget: $300,000
Duration: 2 years

Task 5.6 – Publish guidelines and create an adoption process

Description:

The team will set up milestone deliverables at 25%, 50%, 75% and 100% and will describe the content to be included in each. It will establish and implement a final review and adoption process. A peer review procedure will be established at each milestone. A technical writing team will be created and a consensus reached on the style and voice of the guidelines. The Guidelines will be written and reviewed. A small team of reviewers will focus on the presentation of the information, both graphically and textually.

Personnel: Design professionals, Researchers, Material suppliers, Financial interests, Owners, Building officials, Government agencies

Priority: Essential
Budget: $600,000
Duration: Throughout the project

Task 5.7 – Develop a means for future revisions

Description:

After the guidelines are completed, the team will assess the project and identify future goals, research efforts, etc. that will build upon the work completed. The team will write a framework for the next generation of PBSD related projects. The goal of the task is to provide a plan for the continuing evolution of PBSD. The team will establish a procedure for updating the guidelines

Personnel: Design professionals, Researchers, Government agencies

Priority: Optimal
Budget: $150,000
Duration: 1 year

Challenges

- *Analysis and modeling*

  Developing general methods for design and performance prediction will be a challenge when considering varying performance objectives. The procedures must be relatively easy to implement yet still provide higher reliability than current design methodologies and be reasonably economical.

  Procedures for nonstructural design and analysis will have to be greatly expanded from current standards. This will require a major effort on the part of the product team.

  Because modeling will play a more significant role in PBSD design than it currently does, standards for computer aided design will be necessary. These standards need to insure consistency while allowing creative flexibility.

- *Reliability*

  The incorporation of reliability methods into design procedures will be a challenge. Design professionals will need to begin to think in terms of probability, uncertainty and risk. Quantifying these terms in relation to traditional structural engineering concepts will be difficult but important.

- *Administration*

  As with any adoption process, acceptance from the stakeholders will be one of the most difficult challenges. It will require political and diplomatic skill to bring each of the parties into enthusiastic agreement. The teams should consider using professional facilitators and negotiators to build a strong consensus about the PBSD Guidelines and their use.

- *Example applications*

  It will be a challenge to develop realistic, understandable examples of the application of the guidelines that will achieve sellable conclusions and encourage the use of PBSD.

PRODUCT 6 – Stakeholders' Guide

The Stakeholders' Guide will serve to educate the non-engineering audience about the benefits of PBSD. It will be their reference and planning tool much as the PBSD Guidelines serve a similar purpose for the engineering community. The Guide needs to be written in a non-technical style, and emphasize graphic presentation. The financial information should be presented in a way that will be useful to owners and financial professionals. It needs to communicate the concept and application of PBSD to these primary stakeholders. It will include the following components:

- *Background on codes and performance based design.*

  The Guide should give background on the history of code development and the reasons for moving toward performance based design. It should describe in general terms the principles of PBSD and its benefits over current methods. The goal is to show stakeholders that this move is necessary and that performance based design standards are in their financial and business interests.

- *Financial and other benefits of using PBSD.*

  Tables, charts, equations, examples and text, should convey the advantages and appropriate uses of PBSD in terms of financial and other models. Adoption will require that the document include the issues that stakeholders see as concerns and benefits. It will need to specify and quantify these benefits and provide a mechanism for making incremental changes to current practice.

- *Guidance for implementing PBSD.*

  The owner and financial professionals need to be guided through the process of implementing PBSD. Much more than in current practice these stakeholders will form an integral part of the design team. They must assist in making decisions about the direction of a project and be involved throughout its implementation.

- *Example applications of PBSD*

  The guide will contain example applications of the guidelines, covering structural and nonstructural design, and financial planning issues. The examples will contain technical information for the design professionals as well as nontechnical information for building owners and financial interests.

Task 6.1 – Define content and format of Stakeholders' Guide

Description:

The team will convene a series of workshops with stakeholder representatives to create the format and content of the Stakeholders' Guide. The team will determine the level of complexity of the information and equations presented. The goal is to layout the format for the guide so that it is usable to a non-technical audience. A strong effort will be made to involve owners and financial representatives, as these will be the primary users of the information. Another goal is to be able to quantify the level of effort that will be required of these groups in the planning, design and construction processes, in terms of cost and time. A consensus about the style of presentation will also be reached.

Personnel: Design professionals, Researchers, Financial interests, Owners, Contractors, Material suppliers, Building officials, Government agencies, Legal professionals

Priority: Essential
Budget: $150,000
Duration: 1 year

Task 6.2 Present and explain financial modeling techniques

Description:

The team will present and explain the financial modeling tools developed in the Guidelines and the Risk Management Products. In the same manner as the Guidelines these tools should be presented with different levels of complexity, so that the user can employ the most appropriate to a specific situation. The technical and financial research will have been done as part of the **RMP**. In this task the goal is to provide descriptions of and practical ways to employ these tools.

Personnel: Design professionals, Researchers, Financial interests, Owners

Priority: Essential
Budget: $300,000
Duration: Throughout the project

Task 6.3 – Describe the design and construction process

Description:

As with the Guidelines, the team will develop a road map to move from the concept stage to completion of construction, identifying major steps along the way. Retrofit and new design will be considered. The responsibilities and qualifications of each of the stakeholders (including owners and design professionals) throughout the design and construction process will be identified and described. The team will review these responsibilities and evaluate their effects on the groups. The team will prepare the information using

language, figures, equation styles, procedures for implementation, etc., consistent with the Guidelines. The team will consult with legal professionals to evaluate possible changes in liability.

Personnel: Design professionals, Owners, Financial interests, Building officials, Government agencies, Legal professionals

Priority: Optimal
Budget: $250,000
Duration: 2 years

Task 6.4 – Develop examples for the guide

Description:

The team will develop a series of examples for the financial and engineering application of PBSD, which will serve as teaching and reference tools. The team will set up a verification means and check the examples for accuracy and acceptability. The examples will include photographs and other graphic aids to increase understanding of the process.

Personnel: Design professionals, Researchers, Financial interests, Owners

Priority: Essential
Budget: $400,000
Duration: 2 years

Task 6.5 – Develop a plan to maintain or monitor the designed performance objective

Description:

The team will identify maintenance needs for nonstructural components, based on type, function, age, etc. It will develop a program that owners can follow, similar to deferred maintenance or tenant improvement, for maintaining the performance quality of existing equipment. A similar program will be developed to maintain and monitor the overall structural performance goals of a building throughout its life, accounting for changes in occupancy, advancements in the state of the art, structural modifications, etc. This information will be published as part of the Stakeholders' Guide. The team will prepare educational material to inform owners, contractors, and others about the procedures for maintaining a building's designed performance.

Personnel: Design professionals, Contractors, Manufacturers, Owners

Priority: Optimal
Budget: $250,000
Duration: 1 year

Task 6.6 – Publish the stakeholders' guide

Description:

The team will set up milestone deliverables at 25%, 50%, 75% and 100% and will describe the content to be included in each. It will establish a final review and adoption process. The team will also include a nontechnical background and history of the PBSD process and of current code evolution. The goal will be to show the non-engineering audience the need for PBSD and the expected changes with respect to the current design and construction practice. A peer review procedure will be established at each milestone. A writing team will be created and a consensus reached on the style and voice of the guide. A small team of reviewers will focus on the presentation of the information, both graphically and textually. This group will have the responsibility, along with the steering committee of ensuring that the presentation compliments the Guidelines themselves.

Personnel: Design professionals, Financial interests, Owners, Government agencies, Outside experts in information outreach

Priority: Essential
Budget: $400,000
Duration: Throughout the project

Task 6.7 – Develop a means for future revisions

Description:

The team will set up dates for considering revisions to the Guide and a procedure for doing so.

Personnel: Design professionals, Owners, Financial interests, Government agencies

Priority: Optimal
Budget: $100,000
Duration: 1 year

Challenges

- *Cost*

  Turning PBSD into a reality will require substantial investments of time and money by all stakeholders. Stakeholders will need to be convinced that spending money up front will be in their long-term financial interests. Lessons should be taken from other successful efforts, or from other countries such as Japan.

- *Administration*

  The Stakeholders' Guide will need to function well with the PBSD Guidelines. Owners and other non-engineering stakeholders will primarily use the former while design professionals will use the latter. Each, however, must lead to complimentary results that meet the needs of all parties. Close collaboration of both teams will be important. This will present special challenges for each because of the differences in their training and expertise.

- *Education and Incentives*

  A focus of the Guide will be to make the concepts of risk and reliability understandable to all parties. PBSD incorporates reliability-based design, a concept that design professionals often only consider peripherally. Owners and Financial interests, however, use risk management on a regular basis. It will be a challenge to communicate to design professionals that uncertainty must be included in their design approaches, and to convince owners that there are limits on what can be known or anticipated regarding building performance.

Interrelation of Products

It is important to consider the six products as interrelated. It will not be possible to develop PBSD by isolating each as an independent project. This section describes some of the necessary relationships between the products and identifies key crossover lines between the various product teams.

The Technical Reference Products

The **SPP, NPP** and **RMP** will contain the bulk of the research, analysis and testing necessary to develop PBSD guidelines. Generally, these efforts will be developed concurrently throughout the project. However, there are some important commonalties that should be developed first, including:

- *Development of performance levels and global acceptability criteria.*

  This is necessary to establish a common basis for analysis and the development of the standards. Prior to the start of focused research, the three teams should reach a consensus on the definitions of performance and acceptability.

- *Hazard quantification and prediction.*

  The identification of hazard parameters impacts all three products and should be consistent between them. Researchers and design professionals developing this information will to some extent be working concurrently with the structural, nonstructural and risk teams. Before these teams make assumptions regarding hazard evaluation and characteristics, however, agreement on these issues is needed. This will require greater interaction between design professionals and scientists.

- *Reporting methodologies.*

  Each product should report information in a consistent manner, to make the eventual synthesis into the Guidelines and Stakeholders' Guide easier. Reporting formats should be developed at the beginning of the project. Milestones should be put in place to compare progress and track that basic assumptions are consistent between the groups. It will be the function of the steering committee to make sure that each team is meeting its schedule. However, several members of the technical product teams will likely be part of the Guidelines teams as well. Conflicts about fundamental goals and reporting styles may create problems in the development of the Guidelines.

The End Use Products

The PBSD Guidelines and the Stakeholders' Guide are the products that will ultimately be used to implement PBSD. They need to compliment and supplement each other, not duplicate information, and work toward the same overall goal. To this end, both teams working together should perform several tasks.

- *Set goals with stakeholders.*

  While each product will be developed for somewhat different audiences, many of the goals will be the same. Each of the goals identified by the stakeholders should be accounted for in one or both of the products. Stakeholders' forums should be held with the product teams early on and regularly throughout the project, to make sure that no important goal is missed.

- *Develop document outlines.*

  To insure that these products do not miss information or undesirably duplicate it, the outlines for each should be developed in a unified setting. Planning sessions should be held to make sure that both will be compatible.

- *Coordinate example applications.*

  Because of the tight overall project schedule, much of the efforts for these two products will be done concurrently. At the point when the Guidelines are technically complete, the two teams should meet to agree on the content and style of the examples to be included in the Stakeholders' Guide.

Hand over between the Technical and End Use Products

The project schedule requires that work be done in a manner that moves forward quickly. Obviously, developing accurate, reliable and acceptable information is of utmost importance. The quality of the products should not be sacrificed to meet the schedule. However, since the consensus process typically involves compromise and reevaluation, valuable time may be lost if the end use products are begun before substantial progress is made on the technical products. To make the hand over more efficient the following tasks should be performed:

- *Convene technical acceptance workshops.*

  Before the process of distilling the technical products into the end use products at each phase (25%, 50%, 75% and 100%) begins, review should be implemented to "sign-off" on the former. A representative group of stakeholders needs to come to agreement that significant research has been completed and that there is enough information to begin developing the Guidelines. If substantial research is needed during the writing of the guidelines, this could snowball, causing reworking of all the technical products. This is to be avoided.

➢ *Check that the technical products are on the right track:*

At milestones during the technical product development, the members of the end use product teams should confirm that the right information is being produced to facilitate development of the guidelines. To this end, early in the development of the technical products these teams need to prepare outlines of the end use products, so that they or the steering committee can see that work is moving on the right track.

Development of Education Program

Two keys to the success of the education program will be having valuable information published in an understandable and exciting way, and recruiting experts to present this information. It may be unrealistic to assume that the members of the product development teams will be most suited to lead these efforts.

➢ *Translate technical material into easy to understand educational and promotional material.*

The team responsible for developing the education program will meet with representatives from the other product development teams to identify material which would be useful. They will work together to prepare technically accurate information while at the same time, keeping the product beneficiaries in mind. The representatives will review material developed by the team for accuracy.

➢ *Recruit and train experts to present educational material*

The education teams will identify people who are gifted in presenting and teaching, and have a strong knowledge of the PBSD products. These people may not be members of the other product development teams. If this is so, the teachers will need to have close interaction with the product team members to fully understand the concepts that need to be conveyed. The team will develop teaching and presentation programs and train the teachers on presentation methods. The teachers will eventually receive feedback from the seminars they give. The education team will use this information to refine the program.

An effort should be made to bring the concepts of PBSD into universities, so students in engineering, architecture and construction management programs will be familiar with and embrace PBSD concepts when they enter their professions.

Conclusion

Few lives have been lost in major American seismic events, in buildings designed under modern codes. The economic losses in recent earthquakes, however, have put a strain on communities, owners, lenders, insurers, governments and building users. It must be said, too, that none of these events have been of a level that would typically be considered catastrophic. Temblors with a magnitude similar to the 1812 New Madrid or 1906 San Francisco earthquakes will likely result in losses that are several times larger than anything previously experienced if they occur in a densely populated area.

There has been much miscommunication between design professionals, owners and financial institutions about the performance that buildings built to modern codes are expected to deliver. This has led to higher than appropriate expectations by owners.

Owners, however, must be able to make reliable financial decisions about a building's seismic performance. Their long-term capital planning strategies require that seismic risk be translated into meaningful, quantifiable terms. Engineers need ways to design buildings with a predictable level of performance that can be adjusted to meet the owner's needs.

Performance based seismic design represents a bold new strategy for reducing earthquake losses. It focuses on the economic goals of building stakeholders and integrates financial modeling with the latest engineering research. This *Action Plan* lays out a rational, cost-effective and achievable program for establishing and implementing PBSD in a manner that will benefit each of the groups with a stake in the built environment.

The organization of this project around six "products" insures that the critical areas of research and implementation are addressed. It breaks the overall effort into manageable units and produces valuable, self-contained material at regular intervals. It brings together a diversity of opinions, interests and expertise to produce robust and widely acceptable guidelines. The products themselves will rely upon various media to most effectively disseminate information.

The tasks within each product are designed to address the major challenges that will arise, and provide clear guidance for the development teams. Establishing a steering committee and education program insures that administration and promotion of the project are top priorities.

The budget and schedule are both ambitious. However, flexibility is built into each product by recommending essential and optimal funding levels. Tasks are devoted to *finding* sources of major funding for long term research, testing and education efforts, with the intention of spreading these costs throughout the stakeholder community.

The process of building design and construction must undergo a significant change if it is to meaningfully reduce the potential for disastrous earthquake losses. This *Action Plan* represents a major step towards fulfilling the potential of PBSD and reaping its benefits.

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